BAKER BOTTS LLP

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35.U.S.C. 371

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ATTORNEY'S DOCKET NO. A34873 PCT USA

U.S. APPLICATION NO. 10/018116

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/01576	15 MAY 2000	16 JUNE 1999

TITLE OF INVENTION: EMISSION CONTROL SYSTEM

APPLICANT(S) FOR DO/EO/US: Lutz Fabian, Gunter Krodel, Dietmar Resch and Hort Stelzer

Applicant herewith submits to the United States Designated /Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. ☑ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(I).
4. [ ] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [ ] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] A copy of the International Search Report (PCT/ISA/210)
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [ ] A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. ☑ Other items or information:
    a. ☑ a copy of the International Search Report (PCT/ISA/210)
    b. ☑ a copy of the International Preliminary Examination Report (PCT/IPEA/409)

Copy of International Application WO 00/77452 A1
w/10 pages spec, 4 pages claims and 1 sheet drawings

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
I/DE00/01576	15 MAY 2000	16 JUNE 1999

17. [ ] The following fees are submitted:

Basic National Fee (37 CFR 1.492(a)(1)-(5):

Neither international preliminary examination fee (37 CFR 1.482)

Nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO (1.492(a)(3)) $1,040

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO (1.492(a)(5) $890.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO(1.492(a)(2)) $740.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) (1.492(a)(1)) $710.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $ 100.00

CALCULATIONS PTO USE ONLY		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$	890
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 C.F.R. 1.492)(e)).	$	

Claims	Number Filed	Number Extra	Rate	$	
Total Claims	-20=	0	X $ 18.00	$	0
Independent Claims	-3=	0	X $ 84.00	$	0
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$	890
Reduction by ½ for filing by small entity, if applicable.				$	
SUBTOTAL =				$	890
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$	890
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$	890
				Amt. refunded	$
				charged	$

a. [✓] A check in the amount of $ 890 to cover the above fees is enclosed.

b. [ ] Please charge our Deposit Account No. 02-4377 in amount of $_____ to cover the above fees. A copy of this sheet is enclosed.

c. [✓] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4377. A copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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14 DECEMBER 2001
Date

FILE NO.A34873-PCT-USA-066340.0139

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Fabian et al.		
Serial No.	:	10/018,116	Examiner	:
Filed	:	December 14, 2001	Group Art Unit:	
For	:	WASTE GAS CLEANING SYSTEM		

PRELIMINARY AMENDMENT AND
RESPONSE TO NOTIFICATION OF MISSING
REQUIREMENTS

I hereby certify that this paper is being deposited with the United States Postal Service as Express Mail No. **EU206442660US** in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231

April 19, 2002
Date of Deposit

James J. Maune
Attorney Name

26,946
PTO Registration No

Signature

April 19, 2002
Date of Signature

Assistant Commissioner for Patents

Washington, D.C. 20231

Sir:

In response to the Notice to File Missing Parts Applicants submit herewith a translation of the application as filed.

Please amend the Application as follows:

IN THE SPECIFICATION:

Please substitute the attached Substitute Specification and Abstract for the translation of this application. The Substitute Specification conforms to U.S. Practice and places the application in better English.

IN THE CLAIMS:

Cancel Claims 1 to 19.

Add claims 20 to 38 as follows:

20. **(New)** A waste gas cleaning system for removing harmful and/or toxic gases from a gas stream, comprising:

a reaction chamber having an inlet for receiving a gas stream to be treated and an outlet;

a plasma source coupled to said reaction chamber for providing exitation energy to said chamber and form a plasma therein; and

a liquid jet arranged at said reaction chamber outlet and generating negative pressure in said reaction chamber, said liquid jet being arranged to draw treated gases out of said reaction chamber mixed with liquid from said liquid jet.

21. **(New)** A waste gas cleaning system as specified in claim 20 wherein said liquid jet has a larger cross-section than the cross-section of said outlet.

22. **(New)** A waste gas cleaning system as specified in claim 20 wherein said liquid jet as arranged to generate negative pressure in the range of 30 mbar to atmospheric pressure.

23. **(New)** A waste gas cleaning system as specified in Claim 22, wherein said liquid jet pump is provided with a sorption medium.

24. **(New)** A waste gas cleaning system as specified in Claim 23, wherein there is provided a recirculating system including said liquid jet for said sorption medium.

25. **(New)** A waste gas cleaning system as specified in Claim 24, wherein said recirculating system is provided with a cooling system.

26 **(New)** A waste gas cleaning system as specified in Claim 24 wherein said recirculating system includes a controllable circulation pump for controlling flow rate of the sorption medium.

27. **(New)** A waste gas cleaning system as specified in Claim 26, wherein said circulation pump is a compressed air-driven diaphragm pump.

28. **(New)** A waste gas cleaning system as specified in any of Claims 20 to 27 wherein there is provided a secondary air inlet to said reaction chamber and wherein said secondary air inlet is controlled to control said negative pressure in said reaction chamber.

29. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein there is provided at least one inlet for additional gases to at least one of said reaction chamber and said plasma source.

30. **(New)** A waste gas cleaning system according to Claim 29 wherein said at least one inlet for additional gas is connected with a source for one of oxygen and hydrogen.

31 **(New).** A waste gas cleaning system according to Claim 29, wherein said at least one inlet for additional gas is connected with a source for water vapor.

32 **(New).** A waste gas cleaning system according to any of Claims 20 to 27 wherein said plasma source provides a non-thermal plasma.

33. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein said plasma source has an excitation frequency in the microwave range.

34. **(New)** A waste gas cleaning system according to Claim 33, wherein said plasma source has an excitation frequency of 2.45 GHz.

35. **(New)** A waste gas cleaning system according to Claim 33 wherein said plasma source has a microwave power of up to 6 kW.

36. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein a pH electrode is arranged at an outlet at the liquid jet pump and wherein said pH electrode is connected with a control for a metering pump for providing a metered addition of one of alkaline and acid solution into the liquid jet.

37 **(New).** A waste gas cleaning system according to any of Claims 23 to 27 wherein said liquid jet is connected with a reservoir for the sorption medium and wherein a suction line connects said reservoir with an exhaust for the cleaned waste gas.

38 **(New).** A waste gas cleaning system according to Claim 37, wherein said suction line includes at least one aerosol filter.

REMARKS

Applicants submit herewith a translation of the application as filed and a proposed Substitute Specification and Abstract in compliance with U.S. Practice.

Claims 1 to 19 are cancelled. Claims 20 to 38 conforming to U.S. practice are presented.

A Declaration and Power of Attorney are submitted herewith.

Attached herewith is a **"Version with Markings to Show Changes Made.**

Respectfully submitted,

James J. Maune
PTO Reg. No. 26,946

Attorney for Applicant
(212) 408-2566

Baker Botts LL.P
30 Rockefeller Plaza
New York NY 10112

VERSION WITH MARKINGS TO SHOW CHANGES MADE

20. **(New)** A waste gas cleaning system for removing harmful and/or toxic gases from a gas stream, comprising:

a reaction chamber having an inlet for receiving a gas stream to be treated and an outlet;

a plasma source coupled to said reaction chamber for providing exitation energy to said chamber and forma plasma therein; and

a liquid jet arranged at said reaction chamber outlet and generating negative pressure in aid reaction chamber, said liquid jet being arranged to draw treated gases out of said reaction chamber mixed with liquid from said liquid jet.

21. **(New)** A waste gas cleaning system as specified in claim 20 wherein said liquid jet has a larger cross-section than the cross-section of said outlet.

22. **(New)** A waste gas cleaning system as specified in claim 20 wherein said liquid jet as arranged to generate negative pressure in the range of 30 unbar to atmospheric pressure.

23. **(New)** A waste gas cleaning system as specified in Claim 22, wherein said liquid jet pump is provided with a sorption medium.

24. **(New)** A waste gas cleaning system as specified in Claim 23, wherein there is provided a recirculating system including said liquid jet for said sorption medium.

25. **(New)** A waste gas cleaning system as specified in Claim 24, wherein said recirculating system is provided with a cooling system.

26 **(New)** A waste gas cleaning system as specified in Claim 24 wherein said recirculating system includes a controllable circulation pump for controlling flow rate of the sorption medium.

27. **(New)** A waste gas cleaning system as specified in Claim 26, wherein said circulation pump is a compressed air-driven diaphragm pump.

28. **(New)** A waste gas cleaning system as specified in any of Claims 20 to 27 wherein there is provided a secondary air inlet to said reaction chamber and wherein said secondary air inlet is controlled to control said negative pressure in said reaction chamber.

29. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein there is provided at least one inlet for additional gases to at least one of said reaction chamber and said plasma source.

30. **(New)** A waste gas cleaning system according to Claim 29 wherein said at least one inlet for additional gas is connected with a source for one of oxygen and hydrogen.

31 **(New)**. A waste gas cleaning system according to Claim 29, wherein said at least one inlet for additional gas is connected with a source for water vapor.

32 **(New)**. A waste gas cleaning system according to any of Claims 20 to 27 wherein said plasma in the plasma source provides a non-thermal plasma.

33. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein said plasma source has an excitation frequency in the microwave range.

34. **(New)** A waste gas cleaning system according to Claim 33, wherein said plasma source has an excitation frequency of 2.45 GHz.

35. **(New)** A waste gas cleaning system according to Claim 33 wherein said plasma source has a microwave power of up to 6 kW.

36. **(New)** A waste gas cleaning system according to any of Claims 20 to 27 wherein a pH electrode is arranged at an outlet at the liquid jet pump a pH electrode and wherein said pH electrode is connected with a control for a metering pump for providing a metered addition of one of alkaline and acid solution into the liquid jet.

37 **(New).** A waste gas cleaning system according to any of Claims 23 to 27 wherein said liquid jet is connected with a reservoir for the sorption medium and wherein a suction line connects said reservoir with an exhaust for the cleaned waste gas.

38 **(New).** A waste gas cleaning system according to Claim 37, wherein said suction line includes at least one aerosol filter.

BAKER BOTTS L.L.P.

30 ROCKEFELLER PLAZA

NEW YORK, NEW YORK 10112

TO ALL WHOM IT MAY CONCERN:

Be it known that WE,LUTZ FABIAN, GUNTER KRODEL, DIETMAR RESCH and HORST STELZER , citizens of GERMANY, whose post office addresses are, Zschertnitzer Weg 8, D-01217, Dresden, Germany, Karl-Marx-Strasse 40, D-01109, Dresden, Germany, Ludwig-Kossuth-Strasse 25, D-01109, Dresden, Germany and Alexander-Herzen-Strasse 42, D-01109, Dresden, Germany, respectively, have invented an improvement in:

WASTE GAS CLEANING SYSTEM

of which the following is a

SUBSTITUTE SPECIFICATION

BACKGROUND OF INVENTION

[0001] The invention relates to a waste gas cleaning system for the disposal of environmentally harmful and/or toxic gases or vapors having a reaction chamber that is connected with a plasma source in which a plasma is formed by coupled excitation energy, where the reaction chamber and/or the plasma source has at least one inlet for the feed of gases or vapors and the reaction chamber has an outlet for the gases or vapors treated in the plasma source and/or in the reaction chamber.

[0002] A variety of methods have been disclosed for cleaning environmentally harmful and/or toxic gases or vapors, such as for example waste gases coming from semiconductor manufacturing processes such as CVD, LP-CVD, plasma-CVD, plasma etching or similar processes. In the great majority of cases, methods in which the gases or vapors are burned and/or thermally decomposed are used. The thermally treated gases or vapors are then passed

through a scrubber in which the solid and/or soluble reaction products are scrubbed out of the waste gases by means of a sorption medium.

[0003] Such a device for cleaning waste gases has been disclosed in WO 96/23173. This device contains a combustion chamber in which is arranged a burner and to which are fed burnable gas, oxygen or air and the process waste gas to be decomposed. Above the combustion chamber is located a scrubbing chamber with a spray nozzle for spraying the sorption medium. There the combustion chamber is located within an outer pipe and is limited by an inner pipe, the outer pipe also surrounding the scrubbing chamber that is located above the combustion chamber.

[0004] The reaction products produced in the combustion chamber are passed between the inner and the outer pipes into the scrubbing chamber and from there via an exhaust into the ambient air.

[0005] A wide variety of gases, such as for example, SiH_4, PH_3, B_2H_6, TEOS (tetraethoxysilane) from CVD processes, C_2F_6, CF_4, CH_3F, Cl_2, BCl_3 from dry etching processes and from other processes, can be disposed of with great effectiveness by such a waste gas cleaning system. A requirement is that in each instance, the parameters of the waste gas cleaning system be adapted to the type and quantity of the gases or vapors to be cleaned, so as to ensure that combustion or thermal decomposition takes place under excess oxygen.

[0006] In such waste gas cleaning systems, the relatively high operating costs and great consumption of media are disadvantageous. Also disadvantageous is that many different media (burnable gases, oxygen) are required and that fairly high installation costs are to be expected. In addition, the use of burnable gases requires special care.

[0007] In order to avoid these problems, it has been attempted to make use of low-pressure plasmas for waste gas disposal, such as, for example in

EP-A-0,821 995, the use of a hollow cathode discharge has been proposed. There the disadvantage is that intervention in the vacuum system of the coating or etching system cannot be avoided, so that waste gas disposal may negatively influence the preceding semiconductor process. If this is to be avoided, an additional high-cost vacuum system and possibly a buffer chamber for the temporary storage of process waste gases would have to be provided.

[0008] The use of a plasma source that can work under atmospheric pressure would be more favorable. Such plasma sources are operated at an excitation frequency in the microwave range and are capable of generating a non-thermal (cold) plasma.

[0009] The use of such a plasma for the disposal of environmentally harmful or toxic compounds has already been proposed.

[0010] In this connection, the fact that the plasmas generated often become constricted is to be regarded as disadvantageous. In addition, the plasma volume obtainable is limited by screening effects. As a result, the quantity of disposable waste gas is also limited, so that the quantities of waste gas obtainable in conventional combination systems (burning/thermal decomposition and subsequent scrubbing) cannot be obtained. Therefore particular attention has to be paid to the generation of plasma, in order to avoid the disadvantageous effects listed above. However, even in the most careful design of the plasma source, it is necessary to reduce the pressure in the reaction chamber for ignition of the plasma to some 10 mbar. In addition, the fact that when working under normal pressure the most favorable plasma parameters for conversion of the gases or vapors are not always adjustable proves to be disadvantageous. Additionally, a scrubber is

required to remove the harmful substances remaining in the plasma after conversion of the waste gas.

[0011] Therefore, the object of the invention is to provide a waste gas cleaning system in which use of a plasma source working even at atmospheric pressure permits effective and low-cost disposal of environmentally harmful or toxic gases or vapors.

SUMMARY OF THE INVENTION

[0012] The problem on which the invention is based is solved by a waste gas cleaning system of the type mentioned at the beginning in that the outlet of the reaction chamber is connected with a liquid jet, in that the liquid jet pump generates a negative pressure in the reaction chamber and in the plasma source, and in that the waste gases treated in the plasma or by excited particles are carried out of the reaction chamber together with the liquid carried through the pump, intermixed with the latter.

[0013] A negative pressure in the range of atmospheric pressure down to < 100 mbar can be generated in the reaction chamber by use according to the invention of a liquid jet pump. At the same time, the harmful solid, gaseous and liquid substances still found in the waste gas stream after passage through the plasma are scrubbed out by the liquid jet.

[0014] Owing to the possibility of being able to vary the pressure in the reaction chamber over a broad range, the plasma may be ignited at low pressure, and the plasma conditions may be adapted so that decomposition of the gases or vapors to harmless waste gases is effected as fully as possible. In general, a reduction in pressure leads to an increase in plasma volume, but, on the other hand, the volume of waste gas is increased so that residence time is reduced.

[0015] Care should be taken to see that a plasma source is used that, owing to its structural features, is able to form as homogeneous as possible a large-volume plasma in the required pressure range and one that can be used in continuous operation. The waste gas to be treated can be conducted directly through the plasma of the plasma source or fed immediately behind the plasma source into the reaction chamber and treated by the particles excited in the plasma in the so-called remote plasma.

[0016] In development of the invention, the suction port of the liquid jet has a large cross section in order, on the one hand, to generate the required pumping capacity and, on the other, to prevent obstructions by solid constituents of the waste gas. This also results in especially thorough mixing of the liquid conducted through the liquid pump with the waste gas flowing out of the reaction chamber.

[0017] The negative pressure generated in the reaction chamber by the liquid jet lies in the range of < 30 mbar to atmospheric pressure.

[0018] In order to prevent progressive heating of the liquid in the liquid circuit, a cooling system is used. As a result, the necessary negative pressure that is required, for example for ignition of the plasma, can always be generated by the jet pump in the plasma source and in the reaction chamber.

[0019] In an additional embodiment of the invention, the liquid jet is operated with a sorption medium, where the liquid jet is a part of a recirculating system for the sorption medium. In this way, media costs may be substantially reduced and the effectiveness of disposal increased.

[0020] The recirculating system additionally may have a controllable circulation pump for controlling delivery of the sorption agent, so that the negative pressure generated by the liquid jet can be controlled by controlling delivery of the sorption medium.

[0021] The circulation pump preferably is designed as a compressed air-driven diaphragm pump, since, on the one hand, large flow rate can be obtained and, on the other, long service life can be guaranteed.

[0022] Another possibility for the control of negative pressure consists in that secondary air can be drawn in at the inlet of the liquid jet and control of negative pressure can be effected by controlling the quantity of secondary air.

[0023] In an additional development of the invention, the reaction chamber and/or the plasma source may be provided with at least one feed for additional gases. Such additional gases may be oxygen and/or hydrogen, or water vapor, but alternatively other gases. An increase in the effectiveness of disposal can be obtained with these additional gases.

[0024] Plasma sources that work in the microwave range are preferred, since at relatively high pressures near atmospheric pressure, a non-equilibrium plasma (nonthermal plasma) can be generated on the basis of the very high excitation frequency of for example 2.45 GHz and the associated high field densities, where microwave power is at a level, for example, of 6 kW.

[0025] By non-equilibrium plasma is meant that a number of highly reactive or high-energy particles exist without the average temperature of the waste gas being excessively high. In this way, undesirable reactions, such as for example the formation of nitrogen oxides, are reduced.

[0026] Although it is sufficient to operate the liquid jet with clean water as sorption medium, it may in some cases be advisable to add certain substances in order to improve the effectiveness of scrubbing. For this reason, in an additional development of the invention there is provided after the jet pump a pH electrode, which is connected with a control that drives a metering pump for the metered addition of alkaline or acid solution into the liquid circuit. Thus, metered addition of a basic sorption medium is advantageous when for example acid gases (HF, HCl) are to be scrubbed.

[0027] An additional embodiment of the invention is characterized in that the liquid jet is connected with a reservoir for the sorption liquid and in that a suction line connects the reservoir with an exhaust for the cleaned waste gas.

[0028] It is additionally of advantage when at least one aerosol filter that retains solid and/or liquid aerosols in the waste gas is arranged in the exhaust line.

[0029] For a better understanding of the invention, together with other and further objects, reference is made to the following description, taken in conjunction with the accompanying drawings and its scope will be pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The drawing represents a system in accordance with the present invention.

DESCRIPTION OF THE INVENTION

[0031] The waste gas cleaning system consists of a reaction chamber 1, arranged vertically, and is connected at its upper end with a plasma source 2. Plasma source 2 is arranged so that

excited particles in the plasma source can be fed into the reaction chamber. A microwave source that works at a frequency of 2.45 GHz and is designed for a power of up to 6 kW is a possible plasma source 2.

[0032] The reaction chamber 1 in addition has at its upper end one or more inlets 4 for process gases or vapors to be disposed of, for example. process waste gases from semiconductor manufacturing processes, as well as one or more side inlets 5 for additional gas. Oxygen, hydrogen and water vapor, or a combination thereof, are possible additional gases. When the process gases or vapors and the additional gas are to be fed directly into the plasma source 2, the plasma source 2 should likewise be provided with one or more inlets 4' for the process gases or vapors and one or more inlets 5' for additional gas.

[0033] The lower end of the reaction chamber 1 is provided with an outlet 17, which is connected with the suction port 21 of a liquid jet 3. The liquid jet 3 is part of a recirculating system in which is arranged a circulation pump 6. The circulation pump 6 preferably is designed as a compressed air-driven diaphragm pump that draws the liquid used as sorption medium for the liquid, solid or soluble constituents of the waste gas from a reservoir 7 and delivers it to the jet pump 3.

[0034] The pump 3 has the function of generating, in the reaction chamber 1 and in the plasma source 2, a negative pressure of some 10 mbar for ignition of the plasma and maintaining a negative pressure during treatment of the waste gas and, in addition, the task of pumping the waste gas treated in the plasma out of the reaction chamber 1. The magnitude of the negative pressure generated by the liquid jet 3 depends, on the one hand, on the size of the pump and, on the other, on the quantity of the gases fed in, the quantity of liquid pumped and the temperature

of the liquid (vapor pressure). For this reason, it is advantageous to provide cooling of the liquid or the sorption medium in the liquid circuit. For this purpose, the reservoir 7 may be provided with a cooling system 20.

[0035] The pressure in the reaction chamber 1 is measured by a pressure sensor 8, whose electrical signal controls the circulation pump 6 via a control 9 so that the pressure in the reaction chamber 1 is controlled to an optimal value. A second possibility for pressure control consists in coupling the control 9 with a throttle valve 19 in a secondary air inlet 18, and adjusting the pressure to optimal values via the quantity of secondary air drawn in.

[0036] The sorption medium makes intensive contact in the liquid jet pump 3 with the waste gas that has already passed through the plasma, thereby removing solid and soluble constituents from the waste gas, and flows from the jet pump 3 back into the reservoir 7.

[0037] Located in this return flow is a pH electrode 10, which measures the pH of the sorption liquid flowing past and via a control 11 controls a metering pump 12 by means of which alkaline or acid solution may be metered into the liquid circuit in order to keep the pH within a specified range.

[0038] The waste gas converted in the plasma in the reaction chamber 1 and treated in the liquid jet pump 3 with the sorption medium leaves the reservoir 7 via a suction line 13, which is connected with an exhaust.

[0039] One or more aerosol filters 14, which retain solid and/or liquid aerosols, are accommodated in the suction line 13. These aerosol filters 14 may be cleaned continuously or discontinuously by water and/or sorption medium injected via one or more spray nozzles 15.

This water and/or sorption medium flows back into the reservoir 7, so that the quantity of sorption medium in the liquid circuit is steadily increased.

[0040] In order to avoid overflow, at the floor of the reservoir 7 the consumed sorption medium is drawn off together with solid particles by means of a pump 16.

[0041] A high degree of cleaning effectiveness for fluorocarbon compounds as well as other usual gases found in semiconductor manufacture, such as for example SiH_4, PH_3, NF_3 and NH_3, is obtained with the waste gas cleaning system described when it is operated in the pressure range of about 700 to 1000 mbar and a microwave power of up to about 6 kW. Water vapor, but alternatively oxygen and hydrogen, are fed in as additional gases. Caustic potash solution is used for neutralization of the acid gases (HF) produced in conversion of fluorocarbon compounds or NF.

ABSTRACT

[0042] The invention relates to an emission control system for removing environmentally harmful and/or toxic gases or vapors, comprising a reaction chamber which is connected to a plasma source, whereby plasma is formed in said reaction chamber by injecting excitation energy, and the reaction chamber and/or the plasma source has at least one inlet for the introduction of gases or vapors and one outlet for the gases or vapors which are treated in the plasma source and/or reaction chamber. According to the invention, the outlet of the reaction chamber is connected to a liquid jet pump which produces a low pressure in the reaction chamber and in the plasma source. The waste gases with the plasma or the waste gases which are treated by excited particles are jointly conducted along with the liquid which is circulated through the liquid jet pump, mixed therewith and discharged from said reaction chamber.

[Translation from German]

Waste gas cleaning system

The invention relates to a waste gas cleaning system for the disposal of environmentally harmful and/or toxic gases or vapors having a reaction chamber that is connected with a plasma source in which a plasma is formed by coupled excitation energy, where the reaction chamber and/or the plasma source has at least one inlet for the feed of gases or vapors and the reaction chamber has an outlet for the gases or vapors treated in the plasma source and/or in the reaction chamber.

A variety of methods have been disclosed for cleaning environmentally harmful and/or toxic gases or vapors, such as for example waste gases coming from semiconductor manufacturing processes such as CVD, LP-CVD, plasma-CVD, plasma etching or similar processes. In the great majority of cases, methods in which the gases or vapors are burned and/or thermally decomposed are used. The thermally treated gases or vapors are then passed through a scrubber in which the solid and/or soluble reaction products are scrubbed out of the waste gases by means of a sorption medium.

Such a device for cleaning waste gases has been disclosed in WO 96/23173. This device contains a combustion chamber in which is arranged a burner and to which are fed burnable gas, oxygen or air and the process waste gas to be decomposed. Above the combustion chamber is located a scrubbing chamber with a spray nozzle for spraying the sorption medium. There the combustion chamber is located within an outer pipe and is limited by an inner pipe, the outer pipe also surrounding the scrubbing chamber that is located above the combustion chamber.

The reaction products produced in the combustion chamber are passed between the inner and the outer pipes into the scrubbing chamber and from there via an exhaust into the ambient air.

A wide variety of gases, such as for example, SiH_4, PH_3, B_2H_6, TEOS (tetraethoxysilane) from CVD processes, C_2F_6, CF_4, CH_3F, Cl_2, BCl_3 from dry etching processes and from other processes, can be disposed of with great effectiveness by such a waste gas cleaning system. A requirement is that in each instance, the parameters of the waste gas cleaning system be adapted to the type and quantity of the gases or vapors to be cleaned, so as to ensure that combustion or thermal decomposition takes place under excess oxygen.

In such waste gas cleaning systems, the relatively high operating costs and great consumption of media are disadvantageous. Also disadvantageous is that many different media (burnable gases, oxygen) are required and that fairly high installation costs are to be expected. In addition, the use of burnable gases requires special care.

In order to avoid these problems, it has been attempted to make use of low-pressure plasmas for waste gas disposal, such as, for example in EP-A-0,821 995, the use of a hollow cathode discharge has been proposed. There the disadvantage is that intervention in the vacuum system of the coating or etching system cannot be avoided, so that waste gas disposal may negatively influence the preceding semiconductor process. If this is to be avoided, an additional high-cost vacuum system and possibly a buffer chamber for the temporary storage of process waste gases would have to be provided.

The use of a plasma source that can work under atmospheric pressure would be more favorable. Such plasma sources are operated at an excitation frequency in the microwave range and are capable of generating a non-thermal (cold) plasma.

The use of such a plasma for the disposal of environmentally harmful or toxic compounds has already been proposed.

In this connection, the fact that the plasmas generated often become constricted is to be regarded as disadvantageous. In addition, the plasma volume obtainable is limited by screening effects. As a result, the quantity of disposable waste gas is also limited, so that the quantities of waste gas obtainable in conventional combination systems (burning/thermal decomposition and subsequent scrubbing) cannot be obtained. Therefore particular attention has to be paid to the generation of plasma, in order to avoid the disadvantageous effects listed above. However, even in the most careful design of the plasma source, it is necessary to reduce the pressure in the reaction chamber for ignition

of the plasma to some 10 mbar. In addition, the fact that when working under normal pressure the most favorable plasma parameters for conversion of the gases or vapors are not always adjustable proves to be disadvantageous. Additionally, a scrubber is required to remove the harmful substances remaining in the plasma after conversion of the waste gas.

Therefore, the object of the invention is to procure a waste gas cleaning system in which use of a plasma source working even at atmospheric pressure permits effective and low-cost disposal of environmentally harmful or toxic gases or vapors.

The problem on which the invention is based is solved by a waste gas cleaning system of the type mentioned at the beginning in that the outlet of the reaction chamber is connected with a liquid jet pump, in that the liquid jet pump generates a negative pressure in the reaction chamber and in the plasma source and in that the waste gases treated in the plasma or by excited particles are carried out of the reaction chamber together with the liquid carried through the pump, intermixed with the latter.

A negative pressure in the range of atmospheric pressure down to < 100 mbar can be generated in the reaction chamber by use according to the invention of the liquid jet pump. At the same time, the harmful solid, gaseous and liquid substances still found in the waste gas stream after passage through the plasma are scrubbed out by the jet pump.

Owing to the possibility of being able to vary the pressure in the reaction chamber over a broad range, the plasma may be ignited at low pressure, and the

plasma conditions may be adapted so that decomposition of the gases or vapors to harmless waste gases is effected as fully as possible. In general, a reduction in pressure leads to an increase in plasma volume, but, on the other hand, the volume of waste gas is increased so that residence time is reduced.

Care should be taken to see that a plasma source is used that, owing to its structural features, is able to form as homogeneous as possible a large-volume plasma in the required pressure range and one that can be used in continuous operation. Then the waste gas to be treated can be conducted directly through the plasma of the plasma source or fed immediately behind the plasma source into the reaction chamber and treated by the particles excited in the plasma in the so-called remote plasma.

In development of the invention, the suction port of the liquid jet pump has a great cross section in order, on the one hand, to generate the required pumping capacity and, on the other, to prevent obstructions by solid constituents of the waste gas. This also results in especially thorough mixing of the liquid conducted through the jet pump with the waste gas flowing out of the reaction chamber.

The negative pressure generated in the reaction chamber by the liquid jet pump lies in the range of < 30 mbar to atmospheric pressure.

In order to prevent progressive heating of the liquid in the liquid circuit, a cooling means is used. Thus, the necessary negative pressure that is required, for example for ignition of the plasma, can always be generated by the jet pump in the plasma source and in the reaction chamber.

In an additional embodiment of the invention, the liquid jet pump is operated with a sorption medium, where the jet pump is a part of a liquid circuit for the sorption medium. In this way, media costs may be substantially reduced and the effectiveness of disposal increased.

The liquid circuit additionally has a controllable circulation pump for controlling delivery of the sorption agent, so that the negative pressure generated by the jet pump can be controlled by controlling delivery of the sorption medium.

The circulation pump preferably is designed as a compressed air-driven diaphragm pump, since, on the one hand, great delivery can be obtained and, on the other, long service life can be guaranteed.

Another possibility for the control of negative pressure consists in that secondary air is drawn in at the inlet of the jet pump and control of negative pressure is effected by controlling the quantity of secondary air.

In an additional development of the invention, the reaction chamber and/or the plasma source is provided with at least one feed for additional gases. Such additional gases may be oxygen and/or hydrogen, water vapor, but alternatively other gases. An increase in the effectiveness of disposal can be obtained with these additional gases.

Plasma sources that work in the microwave range are preferred, since here at relatively high pressures near normal pressure, a non-equilibrium plasma (nonthermal plasma) can be generated on the basis of the very high excitation frequency of for example 2.45 GHz and the associated high field densities, where microwave power lies for example at a maximum of 6 kW.

By non-equilibrium plasma is meant that a number of highly reactive or high-energy particles exist without the average temperature of the waste gas being excessively high. In this way, undesirable reactions, such as for example the formation of nitrogen oxides, are reduced.

Although it is sufficient to operate the liquid jet pump with clean water as sorption medium, it may in some cases be advisable to add certain substances in order to improve the effectiveness of scrubbing. For this reason, in an additional development of the invention there is provided in the liquid circuit after the jet pump a pH electrode, which is connected with a control that drives a metering pump for the metered addition of alkaline pr acid solution into the liquid circuit. Thus, metered addition of a basic sorption medium is advantageous when for example acid gases (HF, HCl) are to be scrubbed.

An additional embodiment of the invention is characterized in that the liquid jet pump and the liquid circuit are connected with a reservoir for the sorption liquid and in that a suction line that is connected with an exhaust for the cleaned waste gas is joined to the reservoir.

It is additionally of advantage when at least one aerosol filter that retains solid and/or liquid aerosols in the waste gas is arranged in the exhaust line.

The invention will be explained in detail below by an example. A practical embodiment of a waste gas cleaning system according to the invention is represented schematically in the accompanying drawing.

The waste gas cleaning system consists of a reaction chamber 1, arranged vertically, which at its upper end is connected with a plasma source 2.

There this plasma source 2 is arranged so that excited particles in the plasma source can be fed into the reaction chamber. A microwave source that works at a frequency of 2.45 GHz and is designed for a power of up to 6 kW is a possible plasma source 2.

The reaction chamber 1 in addition has at its upper end one or more inlets 4 for the gases or vapors to be disposed of, for example. process waste gases from semiconductor manufacturing processes, as well as one or more side inlets 5 for additional gas. Oxygen and/or hydrogen and water vapor are possible additional gases. When the gases or vapors and the additional gas are to be fed directly into the plasma source, the latter should likewise be provided with one or more inlets 4' for the gases or vapors and one or more inlets 5' for additional gas.

The lower end of the reaction chamber 1 is provided with an outlet 17, which is connected with the suction port 21 of a liquid jet pump 3. The jet pump 3 is part of a liquid circuit in which is arranged a circulation pump 6. The circulation pump 6 preferably is designed as a compressed air-driven diaphragm pump that draws the liquid used as sorption medium for the liquid, solid or soluble constituents of the waste gas from a reservoir 7 and delivers it to the jet pump 3.

The pump 3 has the function of generating, in the reaction chamber 1 and in the plasma source 2, a negative pressure of some 10 mbar for ignition of the plasma and maintaining a negative pressure during treatment of the waste gas and, in addition, the task of pumping the waste gas treated in the plasma out of the reaction chamber 1. The magnitude of the negative pressure generated by

the jet pump 3 depends, on the one hand, on the size of the pump and, on the other, on the quantity of the gases fed in, the quantity of liquid pumped and the temperature of the liquid (vapor pressure). For this reason, it is advantageous to provide cooling of the liquid or the sorption medium in the liquid circuit. For this purpose, the reservoir 7 may be provided with a cooling means 20.

The pressure in the reaction chamber 1 is measured by a pressure sensor 8, whose electrical signal controls the circulation pump 6 via a control 9 so that the pressure in the reaction chamber is controlled to an optimal value. A second possibility for pressure control consists in coupling the control 9 with a throttle valve 19 and adjusting the pressure to optimal values via the quantity of secondary air drawn in.

The sorption medium makes intensive contact in the liquid jet pump 3 with the waste gas that has already passed through the plasma, thereby removing solid and soluble constituents from the waste gas, and flows from the jet pump 3 back into the reservoir 7.

Located in this return flow is a pH electrode 10, which measures the pH of the sorption liquid flowing past and via a control 11 controls a metering pump 12 by means of which alkaline or acid solution may be metered into the liquid circuit in order to keep the pH at a specified value.

The waste gas converted in the plasma in the reaction chamber 1 and treated in the liquid jet pump 3 with the sorption medium leaves the reservoir 7 via a suction line 13, which is connected with an exhaust, not represented.

One or more aerosol filters 14, which retain solid and/or liquid aerosols, are accommodated in the suction line 13. These aerosol filters 14 may be cleaned continuously or discontinuously by water and/or sorption medium injected via one or more spray nozzles 15. This water and/or sorption medium flows back into the reservoir 7, so that the quantity of sorption medium in the liquid circuit is steadily increased.

In order to avoid overflow, at the floor of the reservoir 7 the consumed sorption medium is drawn off together with solid particles by means of a pump 16.

A high degree of cleaning effectiveness for fluorocarbon compounds as well as for the other usual gases found in semiconductor manufacture, such as for example SiH_4, PH_3, NF_3 and NH_3, is obtained with the waste gas cleaning system described when it is operated in the pressure range of about 700 to 1000 mbar and a microwave power of up to about 6 kW. Water vapor, but alternatively oxygen and hydrogen, are fed in as additional gases. Caustic potash solution is used for neutralization of the acid gases (HF) produced in conversion of fluorocarbon compounds or NF.

Waste gas cleaning system

List of reference numerals

1	Reaction chamber
2	Plasma source
3	Liquid jet pump
4, 4'	Inlet for gases or vapors
5, 5'	Inlet for additional gas
6	Circulation pump
7	Reservoir
8	Pressure sensor
9	Control
10	pH electrode
11	Control
12	Metering pump
13	Suction line
14	Aerosol filters
15	Spray nozzle
16	Pump
17	Outlet
18	Inlet for secondary air
19	Throttle valve
20	Cooling means
21	Suction port

Waste gas cleaning system

Claims

1. Waste gas cleaning system for the disposal of environmentally harmful and/or toxic gases or vapors, having a reaction chamber that is connected with a plasma source in which a plasma is formed by coupled excitation energy, where the reaction chamber and/or the plasma source has at least one inlet for the feed of gases or vapors and an outlet for the gases or vapors treated in the plasma source and/or in the reaction chamber, **characterized in** that the outlet (17) of the reaction chamber (1) is connected with a liquid jet pump (3), in that the liquid jet pump (3) generates a negative pressure in the reaction chamber (1) and in the plasma source (2) and in that the gases or vapors treated in the plasma or by excited particles are carried out of the reaction chamber (1) together with the liquid carried through the jet pump (3), intermixed with the latter.

2. Waste gas cleaning system according to Claim 1, **characterized in** that the liquid jet pump (3) has a great cross section of the suction port (21).

3. Waste gas cleaning system according to Claims 1 and 2, **characterized in** that the negative pressure generated by the liquid jet pump (3) in the reaction chamber (1) and in the plasma source (2) lies in the range of < 30 mbar to atmospheric pressure.

4. Waste gas cleaning system according to Claim 3, **characterized in** that the liquid jet pump (3) is operated with a sorption medium.

5. Waste gas cleaning system according to Claim 4, **characterized in** that the liquid jet pump (3) is part of a liquid circuit for the sorption medium.

6. Waste gas cleaning system according to Claim 5, **characterized in** that the liquid circuit is cooled.

7. Waste gas cleaning system according to Claim 5 or 6, **characterized in** that the liquid circuit has a controllable circulation pump (6) for controlling delivery of the sorption medium.

8. Waste gas cleaning system according to Claim 7, **characterized in** that the circulation pump (6) is designed as a compressed air-driven diaphragm pump.

9. Waste gas cleaning system according to any of Claims 1 to 8, **characterized in** that control of negative pressure in the combustion chamber is effected by the metered feed of secondary air.

10. Waste gas cleaning system according to any of Claims 1 to 9, **characterized in** that the reaction chamber (1) and/or the plasma source (2) is provided with at least one inlet (5, 5') for additional gases.

11. Waste gas cleaning system according to Claim 10, **characterized in** that the inlet (5, 5') for additional gas is connected with a source for oxygen and/or hydrogen.

12. Waste gas cleaning system according to Claim 10, **characterized in** that the inlet (5, 5') for additional gas is connected with a source for water vapor.

13. Waste gas cleaning system according to any of Claims 1 to 12, **characterized in** that the plasma in the plasma source (2) and in the reaction chamber (1) is designed as non-thermal plasma.

14. Waste gas cleaning system according to any of Claims 1 to 13, **characterized in** that the excitation frequency of the plasma lies in the microwave range.

15. Waste gas cleaning system according to Claim 14, **characterized in** that the excitation frequency of the plasma lies at 2.45 GHz.

16. Waste gas cleaning system according to Claims 11 to 13, **characterized in** that the microwave power of the plasma source is up to 6 kW.

17. Waste gas cleaning system according to any of Claims 1 to 16, **characterized in** that there is arranged in the liquid circuit after the liquid jet pump (3) a pH electrode (10), which is connected with a control (11) that drives a metering pump (12) for the metered addition of alkaline or acid solution into the liquid circuit.

18. Waste gas cleaning system according to any of Claims 1 to 17, **characterized in** that the liquid jet pump (3) and the liquid circuit are connected with a reservoir (7) for the sorption liquid and in that a suction line (13) that is connected with an exhaust for the cleaned waste gas is joined to the reservoir (7).

19. Waste gas cleaning system according to Claim 18, **characterized in** that at least one aerosol filter (14) is arranged in the suction line (13).

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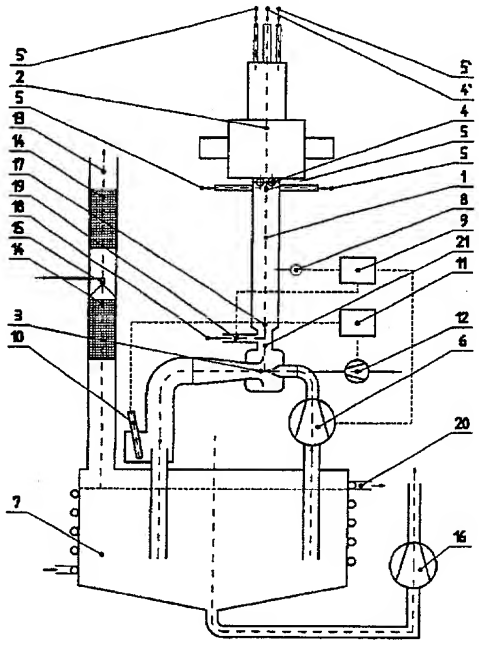
[Fortsetzung auf der nächsten Seite]

(54) Title: EMISSION CONTROL SYSTEM

(54) Bezeichnung: ABGASREINIGUNGSSYSTEM



(57) Abstract: The invention relates to an emission control system for removing environmentally harmful and/or toxic gases or vapors, comprising a reaction chamber (1) which is connected to a plasma source (2), whereby plasma is formed in said reaction chamber (1) by injecting excitation energy, and the reaction chamber (1) and/or the plasma source (2) has at least one inlet (4) for the introduction of gases or vapors and one outlet for the gases or vapors which are treated in the plasma source (2) and/or reaction chamber (1). According to the invention, the outlet (17) of the reaction chamber (1) is connected to a liquid jet pump (3) which produces a low pressure in the reaction chamber (1) and in the plasma source (2). The waste gases with the plasma or the waste gases which are treated by excited particles are jointly conducted along with the liquid which is circulated through the liquid jet pump (3), mixed therewith and discharged from said reaction chamber (1).

(57) Zusammenfassung: Die Erfindung betrifft ein Abgasreinigungssystem zur Entsorgung von umweltschädlichen und/oder toxischen Gasen oder Dämpfen, mit einem Reaktionsraum (1), der mit einer Plasmaquelle (2) verbunden ist und bei dem im Reaktionsraum (1) durch eingekoppelte Anregungsenergie ein Plasma ausgebildet ist, wobei der Reaktionsraum (1) und/oder die Plasmaquelle (2) mindestens einen eingang (4) für die Einspeisung der Gase oder Dämpfe und einen Auslass (17) für die in der Plasmaquelle und/oder im Reaktionsraum (1) behandelten Gase oder Dämpfe aufweist. Erfindungsgemäss ist der Auslass (17) des Reaktionsraumes (1) mit einer Flüssigkeitsstrahlpumpe (3) verbunden, die im Reaktionsraum (1) und in der Plasmaquelle (2) einen Unterdruck erzeugt. Die Abgase mit dem Plasma oder durch angeregte teilchen behandelten Abgase werden gemeinsam mit der durch die Flüssigkeitsstrahlpumpe (3) geleiteten Flüssigkeit und mit dieser vermischt aus dem Reaktionsraum (1) geleitet.

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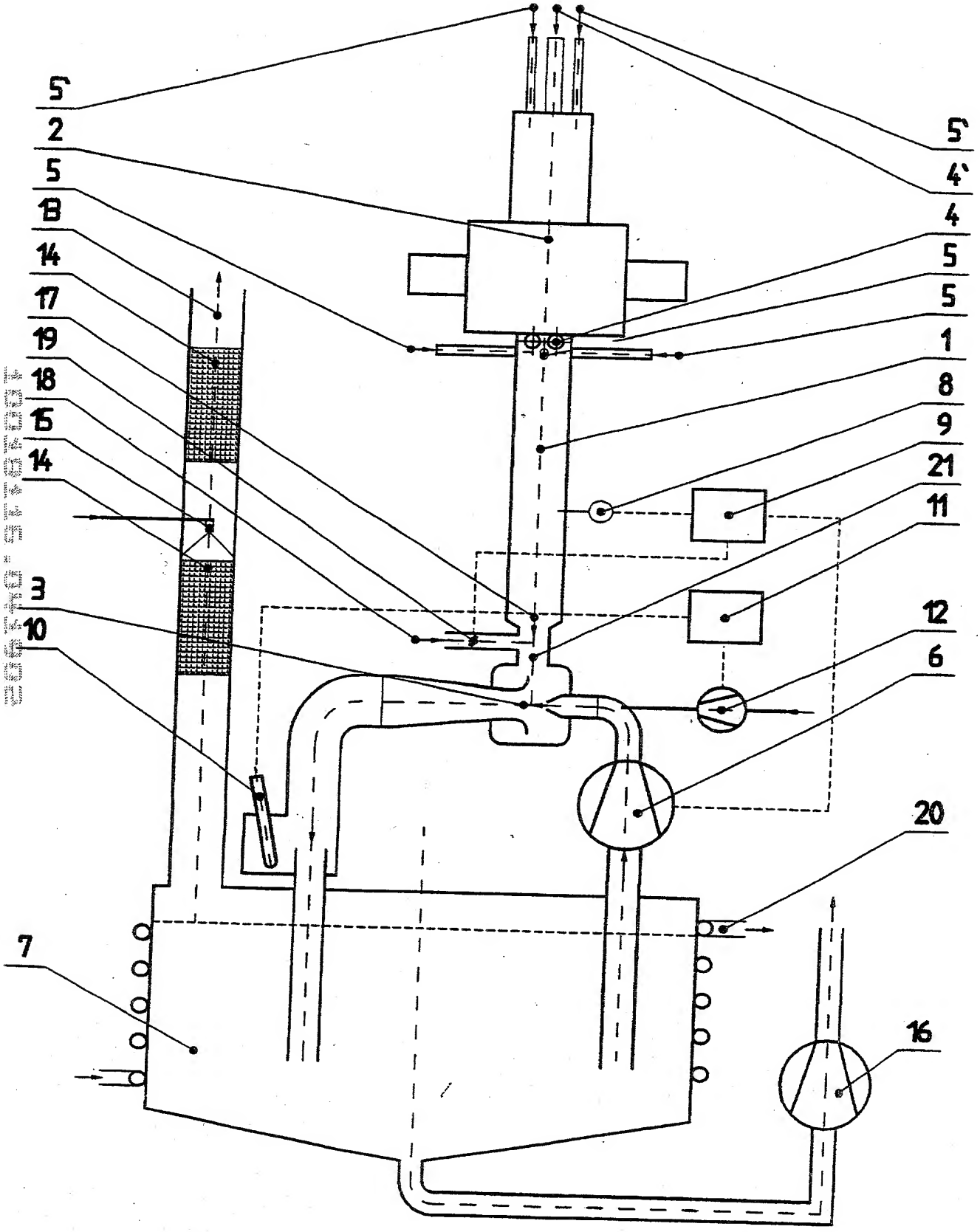
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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☐ Declaration Submitted with Initial Filing OR ☑ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	A34873-PCT-USA-066340.013
First Named Inventor	LUTZ FABIAN
COMPLETE IF KNOWN	
Application Number	10/018,116
Filing Date	December 14, 2001
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

WASTE GAS CLEANING SYSTEM

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 12/14/2001 as United States Application Number or PCT International Application Number 10/018,116 and was amended on (MM/DD/YYYY) _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	Certified Copy Attached? NO
PCT/DE00/01576	GERMANY	06/16/1999	☐	☐	☑
			☐	☐	☐
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

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DECLARATION — Utility or Design Patent Application

Claim for Benefit of Prior U.S. Provisional Application(s)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

Provisional Application Number	Filing Date

Claim for Benefit of Earlier U.S./PCT Application(s) under 35 U.S.C. 120

(complete this part only if this is a divisional, continuation or C-I-P application)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior application(s) in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose information as defined in Title 37, Code of Federal Regulations, Section 1.56 which occurred between the filing date of the prior applications(s) and the national or PCT international filing date of this application:

Application Number	Filing Date	Status (patented, pending, abandoned)

BAKER BOTTS LLP

Attorney Docket Number A34873-PCT-USA-056340.013

DECLARATION — Utility or Design Patent Application

Direct all correspondence to: ☑ Customer Number or Bar Code Label 21003 OR ☑ Correspondence address below

Name

Address

City | State | ZIP

Country | Telephone | Fax

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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☐ Additional inventors are being named on the ____supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

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Please type a plus sign (+) inside this box →

DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page ___ of ___

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Mailing Address	
Mailing Address	
City	State	ZIP	Country